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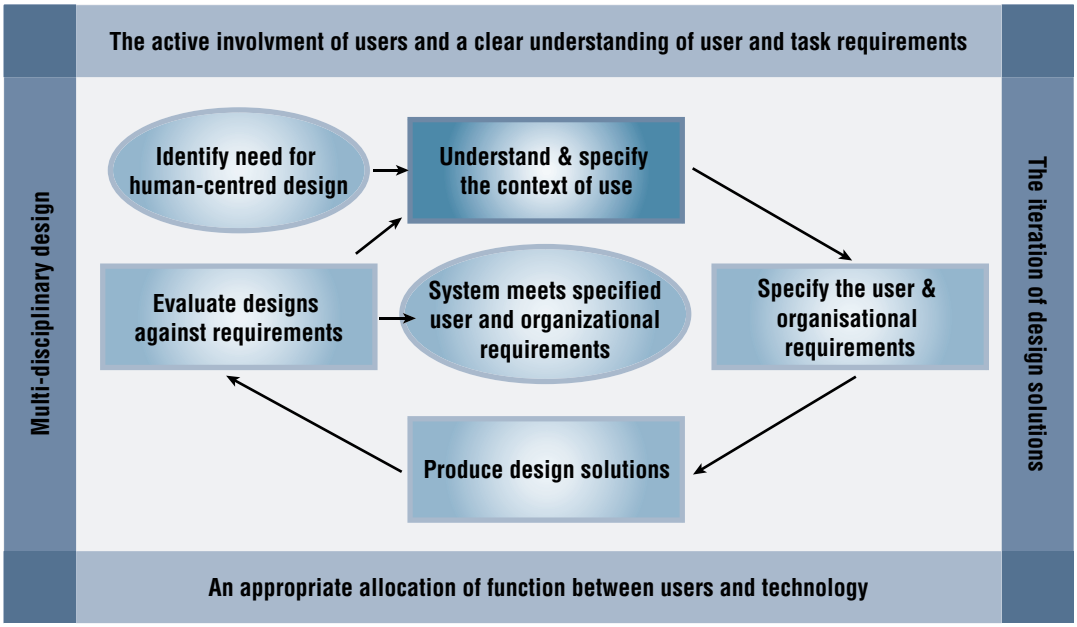

Figure 1. Human-Centred design principles and interdependant design activities as specified in ISO 13407

Human-Centred* Design: Opportunities and Resources

Brian Sherwood Jones
Jonathan Earthy

The revolution in Military Affairs has been followed by a revolution in the Defense Acquisition System. The new DoD Directive 5000.1 [1] represents a major change in acquisition policy and a significant opportunity for Human Systems Integration (HSI). Today, the key characteristics of the Defense Acquisition System are:

- Meeting the needs of the warfighter in the most cost-effective manner
- Co-operation between key stakeholders, and the warfighter in particular
- Ensuring that user need is fully considered in purchasing decisions and trade-offs
- An iterative life cycle/spiral development (drawn from a number of types)
- A system engineering approach
- Integration of user considerations with the rest of the acquisition process (e.g., human systems/information system (HS/IS) integration).

The DoD Joint Technical Architecture (JTA) [2] is referenced in the new DoD Instruction 5000.2 [3] and provides a minimum set of standards that, when implemented, facilitate the flow of information in support of the warfighter. In Section 5.6.3, the JTA states that—

> "ISO 13407, "Human-centered design processes for interactive systems" (1999) [see Figure 1

continued on next page…

*The use of the use of the hyphen and the British spelling of the phrase "human-centred" throughout this article is intended to direct attention to the fact that this phrase, as used in this article, reflects the principles and activities specified in ISO 13407:1999, "Human-Centred Design Processes for Interactiive Systems."

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The Human Systems IAC is a United States Department of Defense Information Analysis Center administered by the Defense Technical Information Center, Fort Belvoir, Virginia, technically managed by the Air Force Research Laboratory Human Effectiveness Directorate, Wright-Patterson Air Force Base, Ohio, and operated by Booz Allen Hamilton, McLean, Virginia.

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above], provides a flexible model for inclusion of critical human systems integration issues into the design process. Use of this process leads to interactive systems that are easier to use, reduces training and support costs, as well as improving user satisfaction and productivity. The process includes active involvement of users to achieve clear understanding of user/task requirements, appropriate allocations of function between users and technologies, and allows for iterative/multidisciplinary design solutions to achieve the systems' interoperability and cost goals."

These benefits are well-established for industrial and government systems around the world (see the web resources and case studies below). The Usability Maturity Model (UMM) [4] is intended to be used in conjunction with ISO 13407 and offers further benefits. This paper gives a very brief outline of the UMM, and sets out some of the HSI opportunities for using it in current acquisition.

The definition of usability in the UMM is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in specified context of use." This broad definition gives HSI the opportunity to provide direct support to warfighter effectiveness.

The seven processes in the UMM have sets of activities or "practices." These practices describe what has to be done in order to represent and include the users of a system during the life cycle of a product or small system. The contents of the model can be summarised as a process hierarchy as shown in Figure 2 below.

Flexibility is the first policy item governing the new Defense Acquisition System [1]. The ability to reflect stage and project context in the performance of processes and practices is one of the main differences between process models and methods/methodologies for system development, such as a traditional Human Engineering Program Plan (HEPP). Because processes focus on achievement, it is possible for the process owner to shift emphasis between processes to meet project need without the risk of being 'tailored out' and of losing effectiveness.

Human-centred life cycles are iterative. Iteration allows the results of user input to be reflected in system design. Most modern software approaches are iterative, providing greater compatibility with Human Centred Design (HCD). UMM is compatible with a wide range of software and system life cycles (a few are identified in the software and system models listed below).

Human-centred processes are not performed in isolation. HCD processes use information from and create information for other system life cycle processes. However, traditional software and human factors (HF) methodologies ignored each other [5] to the detriment of both. These vital interactions have been the subject of recent investigations [6, 7, 8] and appear complicated to achieve at a methodology level. A process approach allows the

HCD 1	HCD 2	HCD 3	HCD 4	HCD 5	HCD 6	HCD 7
Ensure HCD content in systems strategy	**Plan and manage the HCD process**	**Specify stakeholder and organisational requirements**	**Understand and specify the context of use**	**Produce design solutions**	**Evaluate designs against requirements**	**Introduce and operate the system**
•represent stakeholders •collect market intelligence •define and plan system strategy •collect market feedback •analyse user trends	•consult stakeholders •plan user involvment •select human-centered methods •ensure a human-centered approach •plan HCD activities •manage HC activities •champion HC approach •support HCD	•clarify system goals •analyse stakeholders •assess H&S risk •define system •generate requirements •set quality in use objectives	•identify user's tasks •identify user attributes •identify organisational environment •identify technical environment •identify physical environment	•allocate functions •produce task model •explore system design •develop design solutions •specify system and use •develop prototypes •develop user training •develop user support	•specify context of evaluation •evaluate for requirements •evaluate to improve design •evaluate against system requirements •evaluate against required practive •evaluate in use	•manage change •determine impact •customisation and local design •deliver user training •support users •conformance to ergonomic legislation

Figure 2. Human-Centred System Development

interactions to be defined at a higher level, with the promise of a simpler interface and greater flexibility at a project level, whilst still providing explicit usability assurance.

In general, HCD 3–6 form a tight loop at the core of the system development, working with other software technical processes. This loop will be cycled several times during a typical development. HCD 2 provides management and control of human-centred activities, working with project management processes. It uses information generated by the HCD 3–6 loop. HCD 2 also connects the human-centred life cycle to other processes in system development. HCD 1 connects the human-centred life cycle to higher management processes and looks to the future of systems. HCD 1 also sets boundaries and goals for projects which then cycle through HCD 3–6 and are implemented with HCD 7. HCD 7 is concerned with the use of the system. It connects the HCD processes to the support phase of the system life cycle. Throughout the system life cycle, system and software engineers are key users (or nonusers) of HSI outputs.

The UMM is a process model of the same type as software and system engineering models (identified in the software end model section below). This means it has found ready understanding and acceptance among this key user group.

ISO 13407 was written with the project manager in mind, and subsequent work has taken a project view, rather than the more traditional human science focus on HSI activity. This is intended to give additional emphasis to project benefit, rather than technical tools and methods.

Using a process model means that the effectiveness of HSI on a project can be assessed ranging from informal Process Improvement self-assessment (the principal use) through to more formal Capability Evaluation, e.g., for tender award decisions. There has been a debate within the usability and HSI community as to the merits of formal certification (of consultancies, projects, enterprises). This debate is likely to continue for some time. On the one hand, certification offers a number of advantages (e.g., consistency, common language, etc.) to both suppliers and customers (as seen from Software CMM). On the other hand, there are doubts as to whether HSI is sufficiently mature (authors' view: yes), whether the pressure for certification leads to unfortunate side-effects (authors' view: yes, but manageable), or whether a risk-based approach is preferable (authors' view: yes, but only if the culture is right).

July this year saw the publication of the Human-Systems model ISO PAS 18152 [9, 10], known as UMMi. This process model has increased scope, addressing the needs of the 'total system', covering the whole of the system life cycle, and including a Human Resources process.

A range of resources is available to assist people considering the use of HCD and the UMM.

Standards for Human- Centred Design

International standards are available from national standards bodies or from International Organisation for Standardisation, Geneva, Switzerland (www.iso.ch).

ISO 13407:1999 Human-centred design processes for interactive systems. This standard defines basic human-centred design principals and activities.

ISO TR 18529:2000 Ergonomics of human system interaction–Human-centred life cycle process descriptions. This is the standard often known as the Usability Maturity Model.

ISO PAS 18152:2003 A specification for the process assessment of human-system issues. This standard is also known as Usability Maturity Model Integration (UMMi).

Web Resources for Guidance and Support Material

The Human Factors Integration web site, http://www.processforusability.co.uk/HFIPRA/, has material on the standards quoted above and guidance on usability assurance.

The Usability Net web site, http://www.usabilitynet.org, provides a large resource for standards, tools, methods for HCI.

European Usability Support Centres (EUSC) web site pages on Assurance of Usability, http://www.lboro.ac.uk/eusc, include free resources and guidelines.

The FAA HF Process Area, one of the inputs to the UMM, can be found at http://www.hf.faa.gov/docs/508/docs/HF_PA.pdf.

Case Studies

Two case studies are available based on the Usability Maturity Model. One case study describes the experience at Inland Revenue, the other at Israel Aircraft Industries. http://www.usability.serco.com/trump/case_studies/index.htm.

The Inland Revenue was awarded a Central Government Beacon Scheme

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Award for Human-centred design based on ISO 13407.

A number of case studies are given in: Earthy, J.V., Sherwood Jones, B., Bevan, N. The Improvement of Human-Centred Processes—facing the challenge and reaping the benefit of ISO 13407, International Journal of Human Computer Studies, Special Issue (2001) Vol 42, pp. 553–585.

Tailored Application

http://www.e-envoy.gov.uk/Resources/WebGuidelines/fs/en has the 'Quality Framework for UK Government Website Design,' which is based on Human-Centred Design using ISO 13407 and the UMM.

Software and System Models

The following International Standards are of the same form as the UMM.

ISO TR 15504:1998–2, Software process assessment—A reference model for processes and process capability. ISO 15504 has guidance on Process Improvement and Capability Evaluation that is applicable to UMM and UMMi. Support materials can be found at http://www.isospice.com/.

ISO 12207:1995 Software process—Software life cycle processes. ISO 12207 includes a usability process.

ISO/IEC 15288:2002 System engineering—System life cycle processes. ISO 15288 has provided the system-level framework for UMMi.

Details of the Capability Maturity Model, CMM®, for software and CMMI® for systems, together with a wide range of resources to support process approaches, can be found at http://www.sei.cmu.edu/.

Summary and Conclusions

The reference to ISO 13407 in the DoD Joint Technical Architecture, though not as strong as a mandate for the use of human-centred design processes, still serves to advocate for the use of these processes as a means to include consideration of human systems integration issues in the system development process. As such, it provides human factors practitioners and human systems integrators with the opportunity to address human systems issues during system acquisition in a manner that is consonant with existing systems development practices and processes. The publication of the supporting document, ISO 13407, provides a consensus of good practice related to human-centred design and an internationally agreed upon set of essential processes. As is characteristic of process models, it provides guidance as to the ends (goals) that must be accomplished and the types of practices that need to be performed, while leaving latitude with respect to the specific means and methods to be used. Together ISO 13407 and the DoD Joint Technical Architecture serve as a challenge to human factors practitioners and human systems integrators to actively engage in furthering human-centred design processes throughout the life cycle to help ensure the overall usability of systems. ■

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1. Department of Defense Directive 5000.1 May 12, 2003, accessible at http://dod5000.dau.mil/DOCS/DoD%20Directive%205000.1-signed%20(May%2012,%202003).doc.
2. Department of Defense Joint Technical Architecture (JTA), Version 5.0, signed out on 21 August 2003, accessible at http://jta.disa.mil/.
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8. Dugger, M., Parker, C., Winters, J., Interactions Between Systems Engineering and Human Engineering October 28, 1999, ONR/SC-21 Science and Technology Manning Affordability Initiative Thrust 3—Human-Centred Design Environment at http://ww.manningaffordability.com.
9. Sherwood Jones, B.M., Earthy, J.V., 'A New Process Standard for HSI: Rationale, Outline and Benefits,' in Human Systems Integration Symposium, HSIS 2003, Vienna, VA on June 2003.
10. ISO PAS 18152:2003 A specification for the process assessment of human-system issues.

Making Data Suitable for Presenting to the Public

Martin N. Anesgart, Ph.D.

Many researchers have been denied the professional recognition of their expertise and accomplishments in public forums because of the sensitive nature of their work. Even unclassified data can be sensitive or proprietary that employers may not want to make public. However, if the material is sensitive simply because of the numbers themselves, researchers can present their main findings without revealing the real data. This article describes two particularly useful methods and illustrates them with randomly simulated data. The hypothetical research involves the relationship between flight hours experience and how much a pilot deviates from a commanded airspeed and altitude.

The first method is known as the "mean rank" procedure. It is the easiest way to desensitize the data while maintaining as close as possible the research relationships by converting the real data to ordinal data. Ordinal data show whether something is larger or smaller than another without specifying the degree of difference. In a later section discussion will center on the second method of "odds ratio."

Table 1 (see page 6) depicts made-up data for 20 pilots. Each pilot, differing in flight experience (in hours), tried to maintain a constant airspeed (in knots) and altitude (in feet). The study measured the errors, or how much the pilot diverged from the target. In this case, there is a concern that such performance data might reveal critical information about the aircraft's performance characteristics.

The pilots with less than 750 flying hours were categorized as low experience and above 750 flying hours were categorized as high experience. If the experience criterion of 750 hour is considered sensitive, we could simply refer to them as high and low, without specifying the criterion.

Table 2 (see page 6) shows that the first step in converting the data is sorting the performance data in ascending order. These are actually two tables in one, with the rank position number in the center and the two sets of data on each side, with the pilot's subject number on the outside. These can be sorted manually, or if you have a lot of data, a word processor table or a spreadsheet can sort them automatically. Some statistical packages, such as SPSS [1], will perform the entire "mean rank" automatically. In randomly fabricating the data, we ended up with some repeated numbers that illustrate "tied ranks."

In step 2 we replace the position numbers by rank scores, as shown in Table 3 (see page 8). Notice where real scores repeat, they are replaced with the average of the ranks. For example, under Airspeed Deviation there are four "0.08"s occupying positions 13, 14, 15 and 16. The sum of these four is 58, which divided by 4 gives the "mean rank" of 14.5. In the same way, Step 2 will then be performed on the Altitude Deviation values, but showing that is redundant, and not needed for illustration.

Figure 1 (see page 7) uses bar graphs to plot the real data. Figure 2 (see page 7) depicts the results of applying the mean ranking procedure to the data. Notice that both figures display similar ratios for the variables of the study, but in Figure 2 the application of the mean rank procedure shows the relation without revealing the sensitive values. For Airspeed Deviation the height of the ">750" experience group is 63 percent of the "<750" group in the first figure; in the second figure the bar height of the high experience group is 66 percent of the low. For Altitude Deviation the respective proportions are 67 percent and 70 percent.

An advantage of the mean rank pro-

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Pilot	Flight Hours	Speed Deviation-Mach	Altitude Deviation-Feet
1	104	0.10	1000
2	144	0.04	1400
3	220	0.08	190
5	342	0.08	1120
5	348	0.08	290
6	458	0.01	70
7	509	0.10	570
8	568	0.06	460
9	684	0.09	610
10	728	0.01	1350
11	765	0.00	60
12	765	0.07	1100
13	765	0.08	240
14	952	0.04	180
15	1034	0.05	1000
16	1160	0.03	50
17	1166	0.03	1100
18	1273	0.09	400
19	1462	0.02	380
20	1772	0.00	220

Table 1. Flight Hours and Performance Scores

Pilot	Speed Deviation-Mach	Rank Position	Altitude Deviation-Feet	Pilot
11	0.00	1	50	16
20	0.00	2	60	11
6	0.01	3	70	6
10	0.01	4	180	14
19	0.02	5	190	3
16	0.03	6	220	20
17	0.03	7	240	13
2	0.04	8	290	5
14	0.04	9	380	19
15	0.05	10	400	18
8	0.06	11	460	8
12	0.07	12	570	7
3	0.08	13	610	9
4	0.08	14	1000	1
5	0.08	15	1000	15
13	0.08	16	1100	12
9	0.09	17	1100	17
18	0.09	18	1120	4
1	0.10	19	1350	10
7	0.10	20	1400	2

Table 2. Step 1 Sort Airspeed and Altitude Deviation Measures

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cedure is that it preserves some of the dimensions of the original data, and even allows readers to analyze the rank data in other ways. For example, Pilots 16 and 17 both have low scores on Airspeed Deviation, associated with the rank of 17.5, but whereas Pilot 17 also has a high score on Altitude Deviation, Pilot 16's score is the lowest. In the relationship between flight hours experience and the deviation measures, both correlations of the actual data and of the ranks reveal negative or inverse correlations for Flight Hours Experience and Airspeed Deviation (-0.48 for the actual and -0.43 for the ranks) and for Flight Hours Experience and Altitude Deviation (-0.28 for the actual and -0.26 for the ranks). In other words the more experienced pilots commit smaller deviation errors, the same results as shown in Figures 1 and 2.

Like correlation coefficients, another dimensionless index is the "odds ratio." The procedure deriving the ratios puts the real data into categories. Categories upon which the odds ratios are based transmit less information about the data than ranks, yet odds are more intuitive and easier to communicate than ranks. To illustrate, while retaining the two experience categories, the two performance measures were also split into two categories, the demarcation drawn at their median values (0.055 Mach for Airspeed and 430 feet for Altitude Deviation). Tables 4 and 5 (see page 7) display sample "odds ratio." A major statistical tool, Logistics Regression, can test both ratios for statistical significance; in both cases no significance ($p > 0.05$).

Table 4 shows the odds of a pilot scoring both low on Altitude and low on Airspeed Deviation are $6x6/4x4 = 2.25$ times more likely than a pilot scoring low on Altitude and high on Airspeed Deviation.

Table 5 shows the odds of a high experienced pilot scoring low on Airspeed Deviation are $7x7/3x3 = 5.44$ times more likely than a low experienced pilot scoring low on Airspeed Deviation.

In summary, there are several methods to desensitize data for public presentation. The "mean rank" procedure and to a lesser extent, the "odds ratio" offer ways of preserving the characteristics of and relationships between the sensitive variables, yet at the same time sheltering the true values. While reporting the real data adds power and precision to a scientist's presentation, the "mean rank" procedure strikes a good balance between the loss of precision needed to protect sensitive information and the gain of enough detail such that interested parties can do their own analysis and interpretation of the data. ■

References

1. SPSS (1999, release 10.0). Chicago: SPSS Inc.

Pilot	Airspeed Deviation	Airspeed Deviation Ranks
11	0.00	1.5
20	0.00	1.5
6	0.01	3.5
10	0.01	3.5
19	0.02	5.0
16	0.03	6.5
17	0.03	6.5
2	0.04	8.5
14	0.04	8.5
15	0.05	10.0
8	0.06	11.0
12	0.07	12.0
3	0.08	14.5
4	0.08	14.5
5	0.08	14.5
13	0.08	14.5
9	0.09	17.5
18	0.09	17.5
1	0.10	19.5
7	0.10	19.5

Table 3. Step 2 Assign Ranks To Each Pilot's Airspeed Deviation

Count of Pilots		Altitude Deviation Scores	
		low	high
Airspeed Deviation Scores	low	6	4
	high	4	6

Table 4. Cross Tabulation of Pilot Scores on the Two Performance Measures

Count of Pilots		Fit Hours Experience	
		low	high
Airspeed Deviation Scores	low	3	7
	high	7	3

Table 5. Cross Tabulation of Flight Hours Categories and Scores on Airspeed Deviation

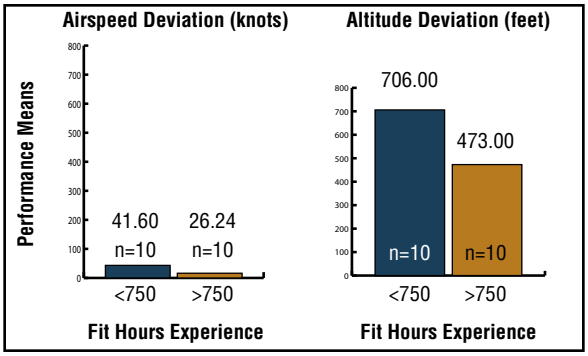

Figure 1. Response Measure Averages: Actual

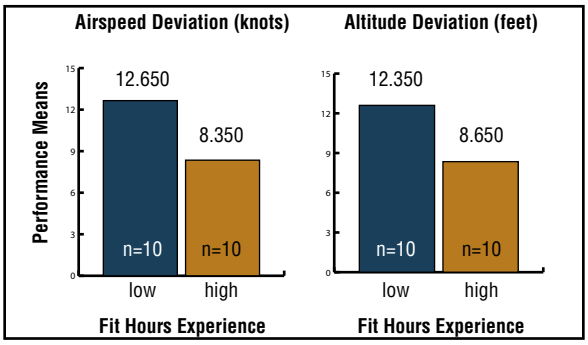

Figure 2. Response Measure Averages: Ranks

MIL–STD–1787
Aircraft Display Symbology

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MIL–STD–1787 defines the standard interface between a pilot and the symbols used on the electronic displays in an aircraft cockpit. It meets two critical needs—

a) Provide criteria for adequate (safe) primary flight displays
b) Standardize the appearance, meaning and behavior of symbols used in military aircraft cockpits

This paper will explain the history of the document, the key requirements of the document and plans for future refinements.

In the mid-1980s the Air Force experienced a number of aircraft mishaps that were attributed to basic flight instrument factors. The USAF Instrument Flight Center, now the Air Force Flight Standards Agency (AFFSA), was tasked by the AF Inspector General to establish a field team to review the latest cockpit designs. The primary direction was to review cockpit flight standardization among the various platforms and the utility of the various flight instrument designs from a human factors perspective (USAF Instrument Flight Standardization, CSERIAC *Gateway*, Vol. 1, Number 4, 1990).

They found that, with the advent of multifunction displays (MFDs), the basic flight instrumentation that the pilots use to fly the aircraft was being displaced in the cockpit in favor of tactical displays. In addition, when basic flight information was displayed on MFDs their design often varied dramatically from one aircraft to another. The concept of the "Basic T" (see Figure 1 below) which provided a consistent and efficient instrument

Figure 1: Basic T

crosscheck, was being violated frequently.

Another problem was that the flight instruments were often being located low and off-center in the cockpit (see Figures 2 and 3, see page 12). This made pilot crosscheck difficult and time consuming, particularly when the pilots were using the Head-Up display (HUD) for some basic flight information and weapons delivery.

Because of this difficult crosscheck, pilots were beginning to use the HUD as the primary flight reference for instrument flight. There was no specification guiding HUD instrument design and the designs varied dramatically across aircraft vendors. To make matters worse, the initial HUDs incorporated in aircraft were only designed for weapon delivery and did not have the reliability required of basic flight instruments. Basic flight information on the HUD was there only to aid the pilot in weapon delivery and help the pilot maintain situation awareness throughout the engagement phase of the mission.

As a result of the evaluation the field team recommended a standard be developed for USAF instrument flight symbology, terminology, and mechanization for both head-up and head-down displays. The report stated, "The standard should address the use of the HUD as a primary flight reference and the presence of a prominent, centrally located primary attitude display" (USAF Instrument Flight Standardization, CSERIAC *Gateway*, Vol. 1, Number 4, 1990). The Cockpit Branch of the Aeronautical Systems Center (ASC) developed the standard in cooperation with several other organizations. Instrument flight symbology research was conducted at ASC and Air Force Research Laboratories (AFRL) including simulations to evaluate symbology presentation and pilot performance. Subjective and objective measures of performance were used in the evaluations. There was particular emphasis on development of a standard HUD format to meet the information and performance criteria.

The initial version of MIL–STD–1787 was published in 1984 as a replacement for the old MIL–STD–884 and retained much of MIL–STD–884's emphasis on symbology size and shape. The most recent update, version C, was published in June of 2001. It changed the emphasis to standardizing the fundamental location and elements of flight symbology, and moved specific design details to a guidance appendix. To date, MIL–STD–1787 has focused on fixed-wing symbology requirements.

The AF asked the Tri-Service Flight Symbology Working Group (FSWG) to participate in the development of MIL–STD–1787. Because of the safety implications involved with the document, the FSWG recommended it be a Tri-Service standard as part of the joint service requirements effort.

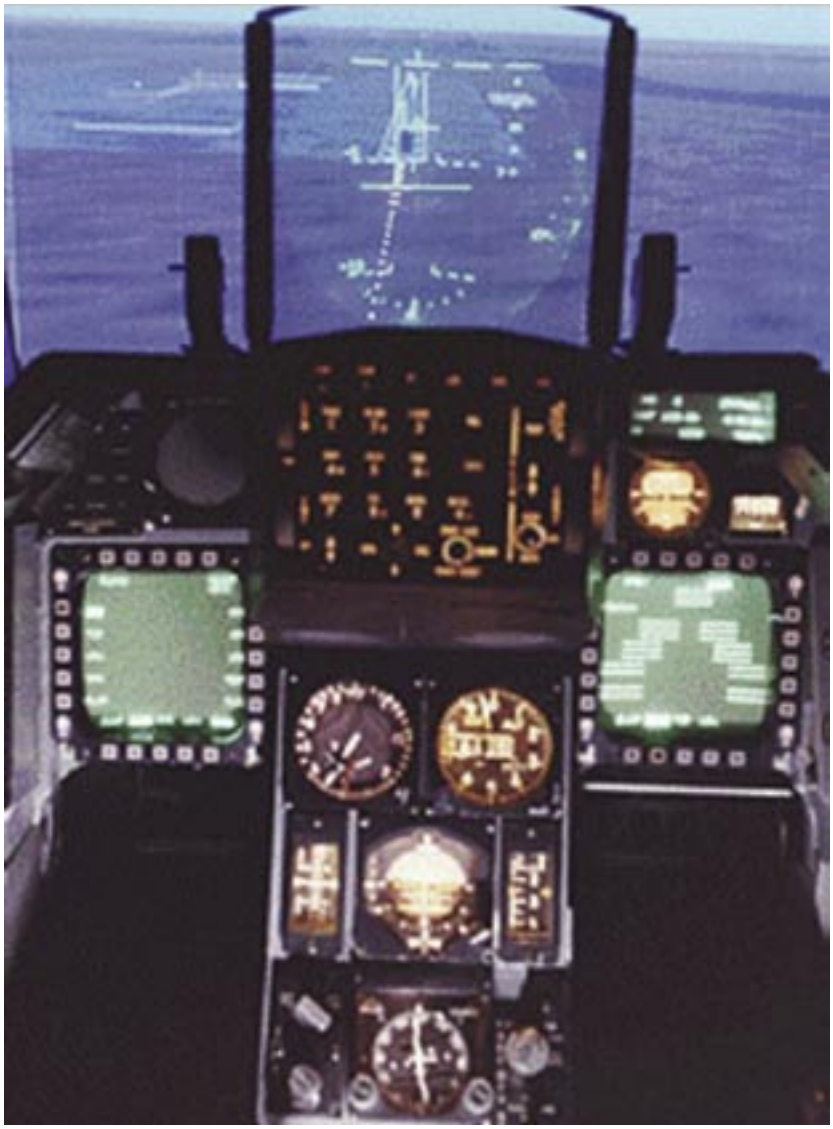

Figure 2: Low Cockpit Instruments

The FSWG was instrumental in keeping MIL–STD–1787 a standard instead of a guidance specification. Flight instrument design is vital to the safety of the aircrew, the ability to carry out the mission and meeting the first rule of flight, "the first job of the pilot is to control the aircraft."

MIL–STD–1787 requirements are divided into two basic sections. The first is flight instrument location, design and information requirements. Flight information requirements are categorized by phase of flight, from take-off to landing. The requirements are definitive and apply to all aircraft. These basic flight requirements are used by the AF Flight Standards Development Group (FSDG) for endorsement of the aircraft primary flight reference(s). The second section describes

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calendar

dec

Orlando, FL, USA. December 1–4, 2003
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URL: http://www.iitsec.org

Las Vegas, NV, USA. December 8–11, 2003
National Ergonomics Conference and Exposition (NECE)
Contact: Walter Charnizon, President, Continental Exhibitions
370 Lexington Avenue, New York, NY 10017
• Tel: 212/370–5005 • Fax: 212/370–5699
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Reno, NV, USA. January 5–8, 2004
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Orlando, FL, USA. March 8–11, 2004
7th Annual Applied Ergonomics Conference
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URL: http://www.iienet.org

Daytona Beach, FL, USA. March 22–25, 2004
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Alexandria, VA, USA. March 29–April 1, 2004
DTIC Annual Users Meeting and Training Conference
Register online after January 5, 2004
Contact: DTIC's Conference Coordinator
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# of events

apr

Chicago, IL, USA. April 2–4, 2004
Society for Industrial and Organizational Psychology Inc.
URL: http://www.siop.org/Conferences/Confer.htm

Tampa, FL, USA. April 20–23, 2004
42nd Annual International Performance Improvement Conference and Expo
Contact: International Society for Performance Improvement
1400 Spring Street, Suite 260, Silver Spring, MD 20910
• Tel: 301/587–8570 • Fax: 301/587–8573
URL: http://www.ispi.org

San Antonio, TX, USA. April 26–29, 2004
ITS America 2004 Annual Meeting
URL: http://www.itsa.org/annualmeeting.html

may

Atlantic City, NJ, USA. May 10–13, 2004
Department of Defense Human Factors Engineering Technical Advisory Group
Contact: Ms. Sheryl Cosing, 10822 Crippen Vale Court, Reston, VA 20194
• Tel: 703/925–9791 • Fax: 703/925–9694• E-mail: scosing@comcast.net
URL: http://hfetag.dtic.mil/meetschl.html

Boston, MA, USA. May 28–June 1, 2004
Association for Behavioral Analysis 30th Annual Convention
Contact: Association for Behavioral Analysis, 1219 South Park Street, Kalamazoo, MI 49001
• Tel: 269/492–9310 • Fax: 269/492–9316 • E-mail: mail@abainternational.org
URL: http://www.abainternational.org

jun

Rochester, MI, USA. June 15–17, 2004
2004 Digital Human Modeling Conference
Contact: Becky Wiley/SAE
• Tel: 724/772–7116 • E-mail: beckyf@sae.org
URL: http://www.sae.org/congress

sep

New Orleans, LA, USA. September 20–24, 2004
48th Annual Human Factors and Ergonomics Society Meeting
Contact: human Factors and Ergonomics Society, P.O. Box 1369, Santa Monica, CA 90406–1369
• Tel: 310/394–1811 • Fax: 301/394–2410 • E-mail: info@hfes.org
URL: http://www.hfes.org

dec

Orlando, FL, USA. December 6–9, 2004
Interservice/Industry Training, Simulation and Education Conference (I/ITSEC)
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tactical symbology requirements. This section can be tailored to fit the specific weapon system under consideration.

The Flight Standards Development Group (FSDG) is a subgroup of the FSWG. It is an AF-only group that has the task of evaluating aircraft primary flight displays for requirement compliance with MIL–STD–1787. The FSDG is composed of display experts from ASC, AFRL, and the AFFSA. Air Force Instruction 11–202 (AFI 11–202), General Flight Rules, states that—

> "…single medium displays must also receive HQ USAF/XOO endorsement as a Primary Flight Reference before they are used as the stand-alone reference for instrument flight"

Aircraft normally have several basic flight instrument displays, a primary head-down, a standby flight group, and one on the HUD. The display that is identified as the "PFR" varies by phase of flight. The HUD typically does not meet the requirements of a PFR when it is in the weapon delivery mode because of the need to minimize HUD clutter and emphasize threat-targeting symbology. MFDs have many formats available to the pilot for various mission functions. These formats can normally be swapped between the displays to enable the pilots to configure the information needed to successfully accomplish the mission. The FSDG is responsible for ensuring that a PFR is displayed within the pilots field-of-view at all times.

MIL–STD–1787 will continue to evolve to ensure that it meets the needs of modern aircraft. The most significant change currently in work is incorporation of rotorcraft requirements. This section is being developed by the U.S. Army and is currently in industry review. ■

Figure 3. Off-Center Instruments

MIL–STD–1787
Aircraft Display Symbology (Rotary Wing Section)

Terry S. Turpin

This article presents the development history and content of the draft Rotary Wing Section of MIL–STD–1787, Aircraft Display Symbology. The Rotary Wing Section is intended to provide direction and guidance to both the procuring agency and the designer of symbology presented on electro-optical cockpit displays in rotary wing aircraft. Use of this standard will result in design solutions that promote improved situational awareness in a reduced visual cue environment (night, adverse weather) and enhance human/cockpit integration. The Rotary Wing Section will be added to the existing fixed wing standard. This integration will be reflected in the publication of MIL–STD–1787D.

The rotary wing section of MIL–STD–1787 was born out of the aftermath of the Acquisition Reform Initiative of the early to mid 1990's, which favored providing guidance to defense contractors as opposed to requiring strict compliance with military specifications and standards. This initiative cancelled a large number of aviation design specifications that were either replaced by guidance specifications such as the Joint Service Specification Guide, 2010, Crew Systems (JSSG–2010), or cancelled without replacement.

One of the victims of acquisition reform was MIL–STD–1295, Human Factors Engineering Design Criteria for Helicopter Cockpit Electro-Optical Display Symbology, dated 1984. This was the primary symbology design document used by the Army for the helicopter fleet which was transitioning into glass cockpits and helmet mounted displays for flight and weapons symbology (AH–64 Apache and OH–58D Kiowa Warrior). When this standard was cancelled in 1996, a large void was created in rotary wing symbology design guidance with nothing to fill it and no way to replace it.

The rotary wing industry needed a solution. In the early 1999 timeframe, a decision was made to add a rotary wing section to the existing MIL–STD-1787, which had survived the acquisition reform axe. At that time, MIL–STD–1787 was a fixed wing only document. It was decided that the lead for development of the rotary wing section would be the Army and the DoD Flight Symbology Working Group (FSWG) would provide guidance concerning structure and content, acting as the steering committee during the development process. The organization with primary authorship responsibility was the Army/NASA Rotorcraft Division, Flight Control & Cockpit Integration Branch, at Ames Research Center, Moffett Field, California.

The scope of the rotary wing section is limited to addressing design criteria for symbolic and alphanumeric information presented on electro-optical displays in rotary wing aircraft. This includes head down, multifunction displays (MFD), head up displays (HUD), and helmet mounted cockpit displays (HMD). This section addresses design criteria for primary flight displays, aircraft systems status, communications, navigation, and weapons information displays. The section is organized in accordance with MIL–STD–962C, DoD Standard Practice, Defense Standards and Handbooks, 1995.

The heart of the rotary wing section begins with Chapter Four, General Requirements. This chapter specifies the use of the systems engineering design process, addresses display of tactical warfighting symbology, and specifies a number of general design principals that should be considered at the conceptual stage of the symbology design process. General design considerations are presented that were derived from human factors issues and functional requirements identified in an analysis of the tri-Service aviation

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domain. It presents high-level design guidance for applications where specific requirements do not exist. General areas addressed in this section include operational considerations that affect symbology design, general design principals, character design, and symbol coding guidance.

With general design considerations defined in the previous chapter, Chapter Five contains detailed design requirements. This chapter defines four flight modes as hover, terrain flight, cruise, and instrument flight. It breaks down the information requirements into categories such as flight, navigation, communications, systems status, and weapons. The chapter then specifies the information requirements by flight mode (required, desired, optional), and by information category (flight, communications, navigation, systems, weapons).

This chapter finally defines the design requirements for each of the individual symbols that the designer may need to display. These symbol design requirements are tailored to address the unique requirements, if any, that must be considered for the three different display types, multifunction display (MFD), head-up display (HUD), and helmet mounted display (HMD). This section of the chapter is intended to be a shopping list of potential symbols that could be displayed. If, for instance, the aircraft requires radar altitude information be presented on an HMD, then the reader simply finds the alphabetical listing for "Altitude, absolute (radar altitude)" and looks under HMD design requirements.

Blanks have been inserted throughout the individual symbol design criteria to allow the designer or procurement office to tailor the requirement. As an example, radar altitude may need to be displayed in more detailed one foot increments when near the earth while ten foot increments are more desirable at higher levels above the ground. The mission and design of the aircraft will determine what these specific numbers and break points should be. The reader will refer to the design handbook located in the appendix to find design tailoring information.

The rotary wing section has four appendices. They are the—

1. Handbook
2. In-Process Verifications
3. Endorsement Process
4. Tactical Symbology

The most important of these is the Handbook. The purpose of the Handbook is to present the rationale, tailoring guidance, and historical lessons learned for each requirement listed in Chapters Four and Five. Lessons learned were gathered from previous research or field experiences that support the design requirement. These experiences were taken from currently fielded and developmental aircraft systems where proprietary information release could be obtained. Pictorial examples of display symbology formats and individual symbols taken from fielded systems assist by giving the developer an example of what has previously been developed to meet the requirement. Use of proven symbol designs may promote standardization and reduce the testing required to prove effectiveness.

The design criteria contained in the rotary wing section is based on findings from research, test, and evaluation of rotary wing systems over the past decade. The data contained in this section is based on the experience gained from the development of fielded and prototype rotary wing aircraft. To the extent possible, specific design requirements were avoided and performance requirements were specified in an attempt to give the designer enough flexibility to allow for the use of innovative technology and unique design solutions.

The rotary wing section is specifically structured for use during the entire symbology design process, from the conceptual phase through the detailed design of individual symbols. It specifies the systems engineering design process, general design considerations for use in the conceptual phase, and finally presents the design criteria for the individual symbols selected for display. It does not attempt to specify the implementation of symbol movement or symbology interaction which are generally considered aircraft mission, design, and series specific.

The Handbook appendix to this section presents rationale for each design requirement, tailoring guidance when applicable, and lessons learned from fielded and developmental aircraft systems. The lessons learned are predominantly attack helicopter oriented. This starting point was chosen because attack aircraft generally have the most sophisticated display suites (MFD, HUD, and HMD), and employ weapons aiming symbology. Other mission categories may be added in later document releases. The rationale and lessons learned section is intended to be a living document that will be updated periodically as funds permit.

Use of this standard will provide design solutions that promote improved situational awareness in night, adverse weather conditions, improved human/cockpit integration, and lower costs associated with qualification and proficiency training.

The rotary wing section remains in draft format. It has been through a complete Government review and is being revised based on comments received. It will be distributed for contractor comments in May 2002. Final incorporation with the fixed wing section and publication is planned with the publication of MIL–STD–1787D, Aircraft Display Symbology. This section of the standard only addresses rotary wing applications. VSTOL applications will be added in later releases. ■

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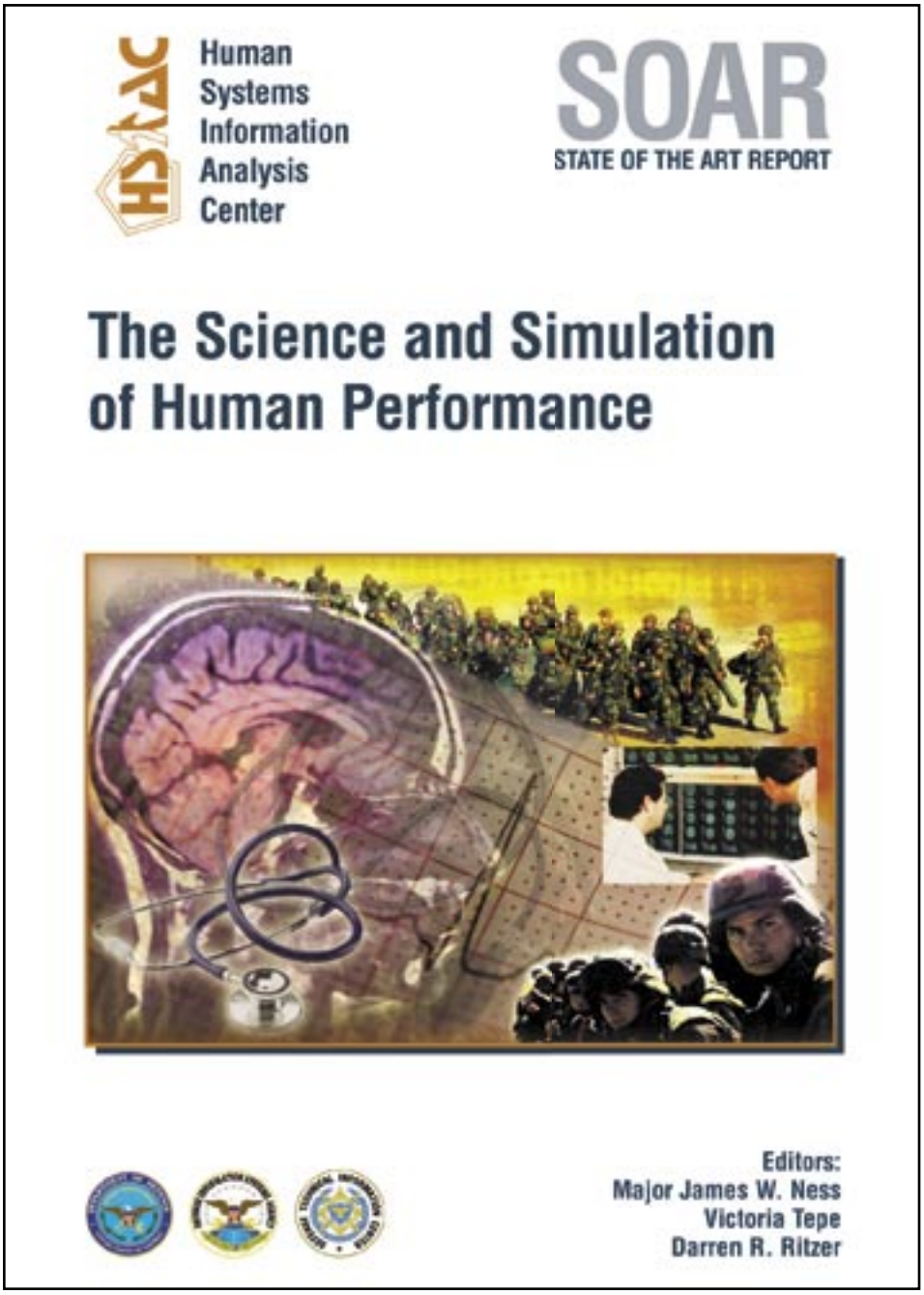

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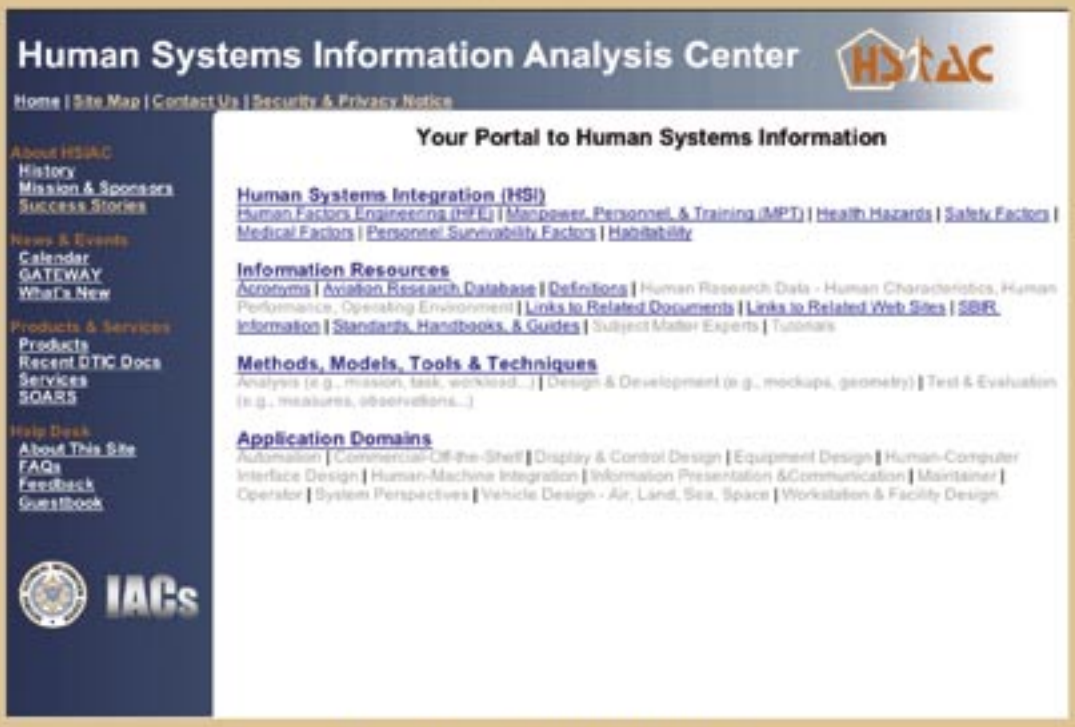

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